SUMMARY OF

A REPORT TO THE
SANTA CLARA COUNTY
FLOOD CONTROL AND WATER DISTRICT

ON THE
BAYLANDS
SALT WATER FLOOD CONTROL
PLANNING STUDY

JANUARY 1973

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Frontispiece: Aerial View of Santa Clara County Baylands, looking west.

One of the nine counties fronting on San Francisco Bay is Santa Clara County, which is situated at its shallow southern end. Large portions of the Santa Clara Baylands are subject to salt water flooding from the Bay caused by high tides and storm-driven waters, and to fresh water flooding from the outfall streams when they are filled with storm waters and their outflows into the Bay are pushed back by wind-driven waves and abnormally high tides. Existing levees, built primarily to bound the evaporation ponds where solar heat and drying winds change the trapped water from salt brine to mountains of white salt, do not provide adequate protection against the extreme events of fresh and salt water flooding. ■

INTRODUCTION

One of the great inland seas of the world is San Francisco Bay, a secluded inlet of the Pacific Ocean covering more than 400 square miles and holding two trillion gallons of salt water. Nine counties and more than thirty cities rim its shores. It harbors the trading ships and planes of the world and the fishing and pleasure boats of the region. It provides facilities along its shores for intensive industrial activities and for neighborhoods of shoreline homes and apartments. In some places, it still provides sheltered tidal flats and marshes and an intricate food web which nourishes a great variety of aquatic animals, wildfowl, waterbirds and marshland animals constituting a unique metropolitan area wildlife resource.

One of the nine counties fronting on the Bay is Santa Clara County, which is situated at its shallow southern end. Within the County there is a Flood Control and Water District which is charged with the responsibility of planning and providing facilities for the protection of life and property within the County from damage from flood and storm waters.

The basic flood problems presently handled by the Santa Clara County Flood Control and Water district are caused by fresh water flowing in the major streams of the County from near their headwaters to their outfalls into San Francisco Bay. In July 1971 the District initiated a study of the problems of salt water flooding along the Bay front and in the Baylands area of the County. The purpose of the study was to develop information that will assist in a determination of whether the Flood Control and Water District should expand its responsibilities to include protection of the Baylands from salt water flooding and how this may be accomplished. ■

STUDY PROCEDURE

The Santa Clara County Flood Control and Water District engaged Tudor Engineering Company, a firm of consulting engineers and planners, to undertake the study. Tudor assembled an interdisciplinary study team consisting of Dr. Andrew H. Trice, economist; Woodward-Lundgren & Associates, soil engineers and geologists; Hydrocomp International, hydrologists; Wildlife Associates, ecologists; and Mark Thomas & Company, Inc., supporting engineers. Additional advisory assistance was obtained from specialists in climatology, tidal hydraulics, sedimentation, and marine ecology. Each team resource specialist analyzed the Baylands area in the light of his particular expertise and in the light of several alternative possible plans which might contribute to a solution of the salt water flooding problem. ■

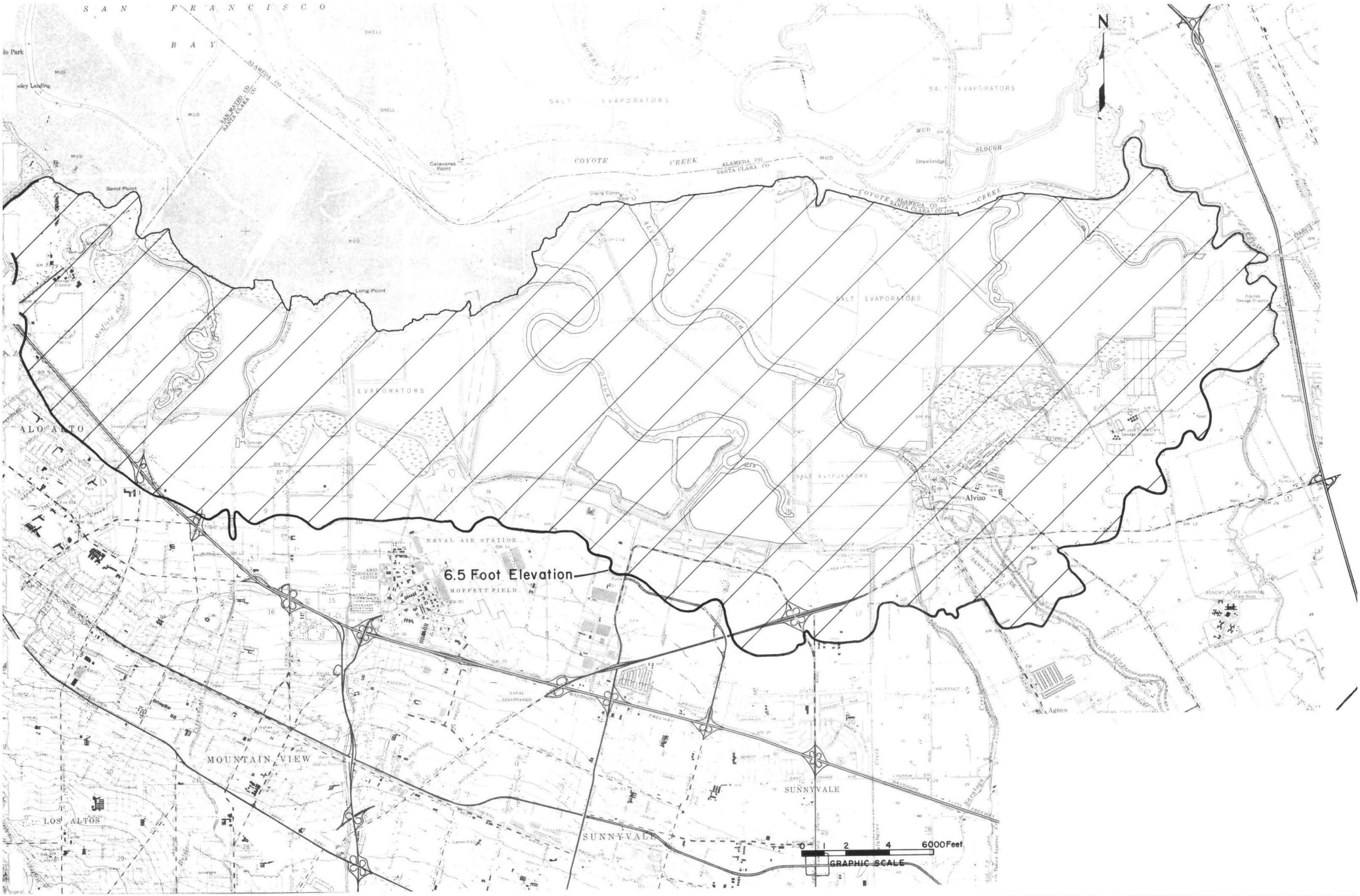
THE BAYLANDS

The Baylands study area consists of that portion of Santa Clara County lying between an elevation of 10 feet above mean sea level and the shoreline, and extends from Coyote Creek near Milpitas on the east to San Francisquito Creek in Palo Alto on the west. In terms of circulation routes, it is generally bounded by the Nimitz Freeway (Route 17) on the east, the Alviso-Mountain View Freeway (Route 237) on the south, and the Bayshore Freeway (U.S. 101) on the west.

Large portions of this area are subject to salt water flooding, and some portions are subject both to salt water flooding from the Bay caused by high tides or from streams affected by the tides under storm conditions, and to fresh water flooding from the streams when they are filled with storm waters and their outflows into the Bay are pushed back by wind-driven waves and abnormally high tides.

Flooding has become a problem of increasing concern because intensive utility, military, industrial and residential activities have located in portions of the low-lying Baylands. In addition, these Baylands have subsided in elevation from 3 to 7 feet in the past 60 years and may subside from 2 to 3 feet further during the next 75 years unless a fully stable groundwater level can be attained through recharge and extraction policies and regulations currently in force. Much of the land in the study area has been removed from tidal action by dikes and levees built to enclose salt ponds on what would otherwise be submerged land, tideland, or swamp and overflowed land. During periods of excessive freshwater runoff, flooding occurs behind some of these levees. Were the levees to be breached under conditions of high tide, strong winds, and heavy rainfall, most of the Baylands would be subject to salt water flooding.

The Baylands study area is an ecologically fragile area that has undergone dynamic structural and environmental change over the past 100 years. The prehistoric broad salt marshes dissected by the meandering brackish tidal sloughs of Coyote, Alviso, Guadalupe and other, lesser, drainages have long been trapped behind earth levees and shaped by dredger and bulldozer. Much of the tidal grasslands and the floodplains have disappeared. They were modified first to stock pasturage and hay farms, then to truck gardens and orchards, and most recently to industrial sites, suburban housing, military installations and aero-space industries, ringed by a complex of teeming freeways. The tidal salt marshes, where the bright green pickleweed flats once provided sprawling miles



GENERAL AREA SUBJECT TO SALT WATER FLOODING

of sanctuary for shorebirds and waterfowl, have been bound within the leveed basins of evaporation ponds where solar heat and drying winds change the trapped water from salt brine to mountains of white salt.

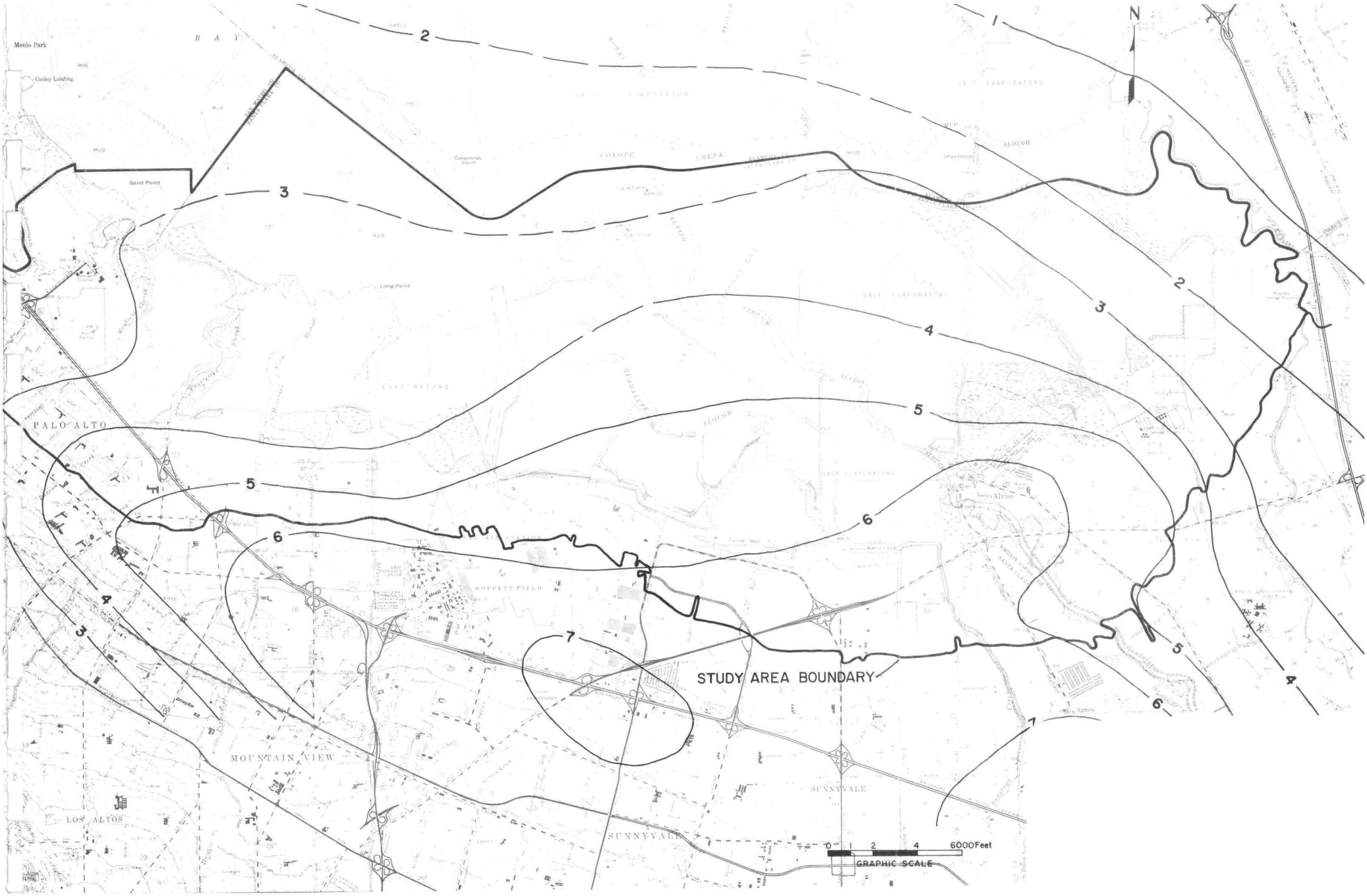
Today only fragments remain of the Baylands as they existed in January 1777, when the Spanish padres founded Mission Santa Clara de Asis alongside the Rio Guadalupe. The padres set out the first of the famed Santa Clara Valley orchards and they found that, besides abundant water in the river, many springs existed for irrigating the fields. The "abundant" water forced the mission to move within a few years, for the river seasonally overflowed.

Closely associated with the early history of the Baylands as well as with Mission Santa Clara, is Alviso, located at the head of Alviso Slough. Ignacio Alviso settled there in 1840 and his name became attached to the community which then served as El Embarcadero de Santa Clara, a shipping point for the hide trade. Large boats or launches lightered cattle hides to trading vessels, and trade in this shipping port increased with the 1849 gold rush. After 1865 and the coming of the railroads, Alviso's brief economic importance subsided. Today, a small craft recreational boating harbor serves to remind of Alviso's relation to the Bay, and three small custom boat works exist. Little remains of the vast tidal marshes that once adjoined this waterfront village: the marshlands are now almost entirely enclosed by salt pond levees.

The dominating urban center whose limits extend into the Baylands is the City of San Jose, founded in November 1777 as El Pueblo de San Jose de Guadalupe, the first agricultural town established in Alta California. As with Mission Santa Clara, the first homes of the settlers had to be moved to high ground above the Rio Guadalupe floodplain. The cattle pastures and grain farming of the first seventy-five years of the area's development began to give way after the American Civil War to fruit farming, an activity that eventually created the largest cannery and dried fruit packing center in the world prior to World War II. Concomitant with this development there were serious environmental impacts on the Baylands. Water tables in Santa Clara Valley began to fall, and land subsidence and increased salt water intrusion became severe. The dwindling water flows in the drainage streams had to transport ever more cannery waste, the streams became polluted, and the anadromous fish runs were lost.

The Bayfront cities of Palo Alto, Mountain View, and Sunnyvale have each played their role in the environmental history of the Baylands, although the adverse impacts have been somewhat less severe on their Bayfront lands than on those at the extreme southern reach of the Bay. Salt water intrusion, land subsidence, falling water tables, and destructive floods have been less severe than those in the floodplains of Coyote Creek, Alviso Slough and Guadalupe Slough. These northernmost of the Santa Clara County Bayfront communities were not settled until the middle or late 19th century, and remained only modestly industrialized until after World War II.

Moffett Field, a military air base, was built after World War I on the Baylands between Mountain View and Sunnyvale. Moffett Field became particularly renowned as the home port for the ill-fated dirigibles Akron and Macon, and the immense hangars built to house these lighter-than-air craft still dominate the Baylands panorama. Other air and aerospace research and development centers now adjoin the



LINES OF EQUAL LAND SURFACE SUBSIDENCE 1934—1967



South Bay Yacht Club, Alviso, 1914



South Bay Yacht Club, Alviso, 1972

Subsidence of the ground surface elevation of the Baylands, due to groundwater withdrawal, has occurred in varying amounts since records were first established in 1912. Alviso, which subsided six feet between 1934 and 1967, is now at an elevation of 2.0 feet below mean sea level.

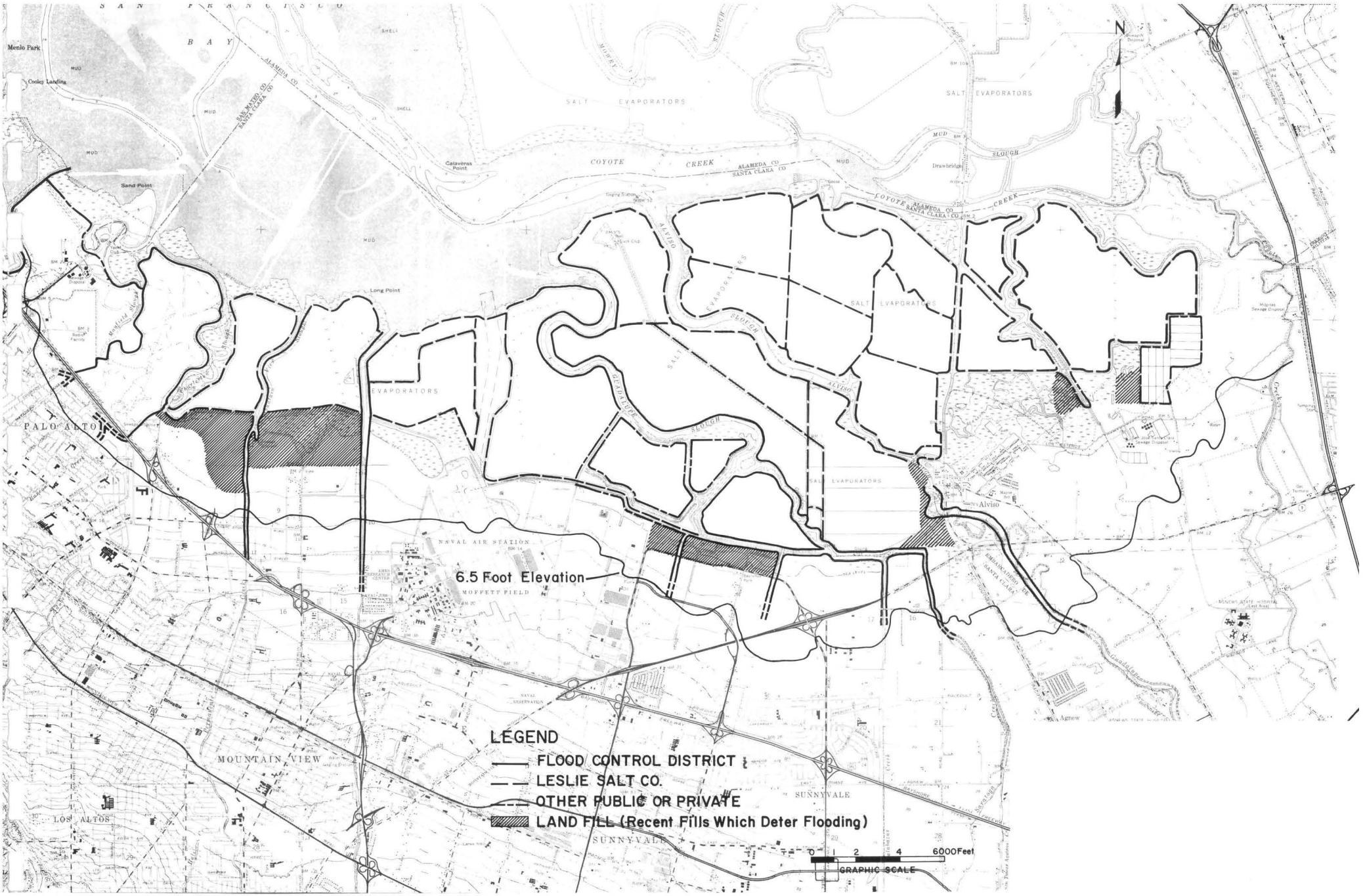
U.S. Naval Air Station at Moffett Field. In all, nearly 3,000 acres of one-time mud flats, tidal marshes and floodplains of the Baylands have become developed for military and industrial uses.

The major direct impact on the Baylands during the past seventy-five years, and the one that has modified the Baylands environment most drastically, was brought about by the development of the salt industry. From the earliest days, crude solar evaporation ponds were built to harvest sea salt. By the turn of the century, much of the tidal marshlands of South San Francisco Bay had been enclosed behind the levees of a host of small salt-producing companies. After World War I, Leslie Salt Company began its phenomenal growth and became one of the largest landowners in the San Francisco Bay Region. Many already existing solar evaporation pond systems were absorbed in toto and incorporated into a single but larger series of brine transport ponds serving Leslie. At present salt water eventually destined for salt harvest in the Newark collecting ponds in Alameda County initially enters the system from Charleston Slough just south of Palo Alto. The water then passes through what had been the ponds of three minor South Bay companies. To avoid over-concentration and to permit the full advantage of gravity flow, additional sea water is taken into the system between the Stevens Creek outfall and the mouth of Guadalupe Slough, and again east of Alviso Slough. The brine is siphoned past Coyote Creek and Mowry Slough, and moved north to Newark. ■

EXISTING LEVEES

The existing levees in the Baylands were constructed primarily to enclose the salt ponds. They bound and "protect" nearly 16,000 acres of land consisting of both developed and undeveloped areas. The basic portion of this levee system, the series of inboard levees, provides a degree of protection to nearly 7,600 acres of land, of which some is intensively developed. The outboard portion of the system extends along the shoreline at the edge of the former marshlands from Charleston Slough to Coyote Creek. These levees bound approximately 8,300 acres of wetlands consisting of salt water evaporation ponds or marshlands. Between the inboard and outboard segments of the existing levee system a series of levees bounds each of the salt ponds and the major fresh water outfall channels and tidal sloughs. The present levees are owned and maintained by several private and public owners and agencies.

The existing levees are of mixed earthwork construction. Bay Mud dredged from alongside the existing levees constitutes the basic construction material, but in some instances along readily accessible alignments of the inboard segment, imported fill materials have been used. Almost without exception, the crest elevations of the levees are below the minimum elevation which conforms with criteria established in this study. The higher levees are found mostly along the major outfall channels, the outer edge of the salt ponds, and along major industrial sites or sewage treatment plants on the inboard segment. The existing levee cross-sections vary considerably and for the most part do not provide adequate protection against the extreme events of fresh and salt water flooding and earthquake shaking considered in the levee design criteria developed for this study. ■



EXISTING LEVEES AND RESPONSIBLE AGENCIES

FACTORS AFFECTING THE BAYLANDS

A number of agencies in addition to the cities fronting on the Bay, have been invested by law with planning and regulatory controls over the use of portions of the area subject to the hazards of salt water flooding. Among the most important of these are the San Francisco Bay Conservation and Development Commission which has adopted a San Francisco Bay Plan. This plan contains a policy that future uses of the vast salt pond area be water-oriented if salt production is terminated. The plan is interpreted by the Executive Director to require that any protection of low-lying areas behind the salt ponds should be accomplished by levees located between the salt ponds and the land inland from them, rather than between the salt ponds and the Bay.

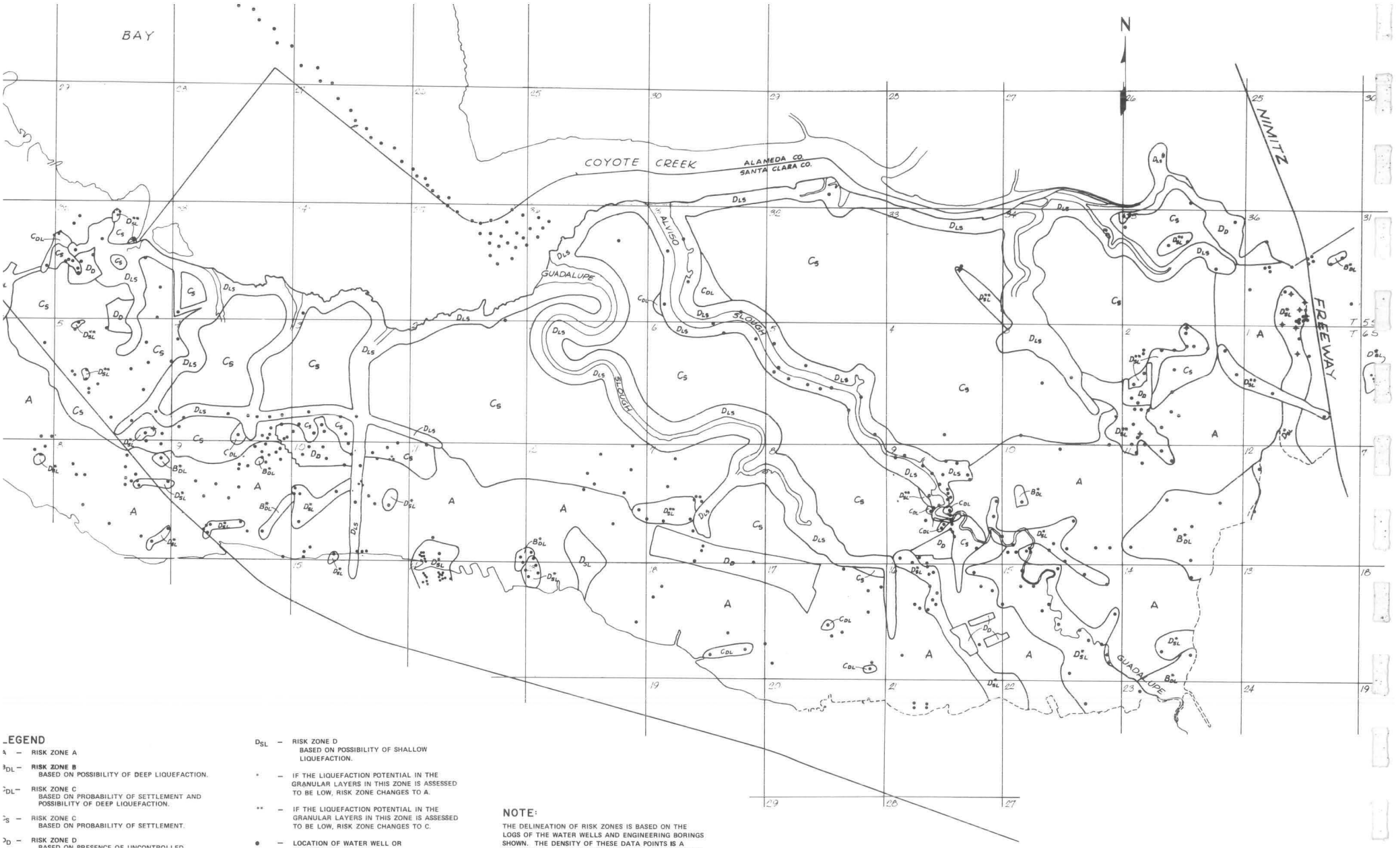
The Army Corps of Engineers is also charged with regulatory authority over the waters of the Bay and over all diked areas which are situated below former mean higher high water. This includes the salt ponds. The Corps has never approved a permit application that has been denied by the Bay Conservation and Development Commission.

The Planning Policy Committee of Santa Clara County, composed of representatives of the County and of the cities in the County, has adopted a Baylands Policy Plan which recommends that levee improvements be made only where needed to protect drylands appropriate for urban development, and that all water areas be preserved and enhanced in concert with the objectives of the Bay Conservation and Development Commission. A National Wildlife Refuge was approved by Congress and the President in 1972 that includes all of the salt pond and wetland area in the Santa Clara County Baylands east of Alviso Slough.

Although the rate of population growth in Santa Clara County is slower than it was during the period of rapid growth during and subsequent to World War II, it is forecast that it will continue at a greater rate than will the population growth in the Bay Area as a whole. However, demands for land for urban purposes in Santa Clara County can be met by the use of lands available elsewhere in the County without requiring the reclamation or development of the wetlands in the Baylands study area.

The ecology, and consequent environmental quality, of the Baylands is of special significance. Although less valuable from the standpoint of waterfowl than areas in the North Bay and Delta, portions of the Baylands are extremely valuable as a habitat for shorebirds. The ecologically most important segments of the study area are tidal mudflats and tidal sloughs which shelter and nourish a great variety of aquatic animals, wildfowl, waterbirds, and marshland animals. If these ecologically valuable resources are to be preserved, management policies to be developed should carefully consider the patterns of access and use of the Baylands for recreational purposes, and preserve some areas as inviolate sanctuaries.

The geology of the Baylands exposes it to two principal hazards. One is the lateral spreading of soil layers and the other is the liquefaction of underlying soil layers. Both conditions can be induced by earthquake shaking, and the area lies between active fault systems in one of the most seismically active areas in the United States. Geologic risk zones have been identified in the area indicating the specific types of hazards which each portion of the area is most likely to experience in the event of a major earthquake. The underlying conditions so identified are also important to decisions affecting the determination of the location and extent of static loading caused by structures and fills. ■



LEGEND

- A – RISK ZONE A
- B_{DL} – RISK ZONE B
  BASED ON POSSIBILITY OF DEEP LIQUEFACTION.
- C_{DL} – RISK ZONE C
  BASED ON PROBABILITY OF SETTLEMENT AND POSSIBILITY OF DEEP LIQUEFACTION.
- C_S – RISK ZONE C
  BASED ON PROBABILITY OF SETTLEMENT.
- D_D – RISK ZONE D
  BASED ON PRESENCE OF UNCONTROLLED DUMP FILL.
- D_{LS} – RISK ZONE D
  BASED ON POSSIBILITY OF LATERAL SPREADING.
- D_{SL} – RISK ZONE D
  BASED ON POSSIBILITY OF SHALLOW LIQUEFACTION.
- * – IF THE LIQUEFACTION POTENTIAL IN THE GRANULAR LAYERS IN THIS ZONE IS ASSESSED TO BE LOW, RISK ZONE CHANGES TO A.
- ** – IF THE LIQUEFACTION POTENTIAL IN THE GRANULAR LAYERS IN THIS ZONE IS ASSESSED TO BE LOW, RISK ZONE CHANGES TO C.
- ● – LOCATION OF WATER WELL OR ENGINEERING BORING.
- ✦ – LOCATION OF ENGINEERING BORING SPECIFYING "LOOSE" SAND.

NOTE:

THE DELINEATION OF RISK ZONES IS BASED ON THE LOGS OF THE WATER WELLS AND ENGINEERING BORINGS SHOWN. THE DENSITY OF THESE DATA POINTS IS A MEASURE OF RELATIVE RELIABILITY OF THE RISK ZONE DESIGNATIONS ASSIGNED. RISK ZONE BOUNDARIES AND DESIGNATIONS MAY CHANGE AS MORE SUBSURFACE INFORMATION BECOMES AVAILABLE

0 1 2 4 6000Feet
GRAPHIC SCALE

GEOLOGIC RISK ZONES BASED ON SOIL CONDITIONS

ALTERNATIVE PLANS CONSIDERED

Three basic alternative plans were analyzed. The first is the "Do-Nothing" Plan. The do-nothing alternative simply implies that nothing would be done to improve the situation which now exists and that the problems of salt water flooding, fresh water inundation, and erosion and overtopping of levees would continue.

In order to evaluate the possible costs of such an alternative it could be assumed that the entire privately-owned area susceptible to salt water flooding would be purchased at the current market value. The area involved lies between the 6.5 foot elevation and the alignment of the inboard levee system and has a net acreage of 6,457. This includes all of the community of Alviso and portions of Sunnyvale and Mountain View. The market value, based on four times the assessed value, is $160,456,000, which is close to $25,000 per acre overall. These figures do not include the governmental installations of NASA or the Naval Air Station, or locally owned public lands. Local floodplain zoning controls, such as those recently adopted by Mountain View, could decrease the extent of undeveloped acreage that would have to be acquired under this alternative. The removal of this area from the tax rolls would result in an annual loss of taxes to the local communities and the County of more than $4,000,000.

As an alternative to purchasing the entire flood-prone area inboard of the inboard levee alignment it would be possible to fill the area to an elevation above the high tide. It is estimated that the amount of material required to fill the area and provide about three feet of freeboard would be about 65,000,000 cubic yards. The cost of providing this amount of material from inland sources would be about $260,000,000.

The filling of the area could also be accomplished by sanitary fill using solid wastes generated in the Bay Area. With this type of fill material the area would be limited to essentially non-structural uses such as parks and recreational uses. The area would have to be publicly purchased before filling so the initial cost and tax loss would be as indicated above. The benefits resulting from this use have not been estimated as this was beyond the scope of this study.

The social costs of the Do-Nothing alternative to the flood control problem in the Baylands is in some respects inestimable. The loss of lives--up to 1,300 in Alviso alone--in the event of a 100-year flood cannot be measured in dollars alone. The alternative of relocating residents from the area to land above the level of high tides also has immeasurable aspects of social and community disruption which greatly exceed the measurable dollar costs. To do nothing with the existing levees may appear at first to be the least costly of the alternatives, but coping with the consequences in a positive and measurable way results in the Do-Nothing alternative becoming the most costly of the alternatives, as summarized below. ■



Alviso, July 1971

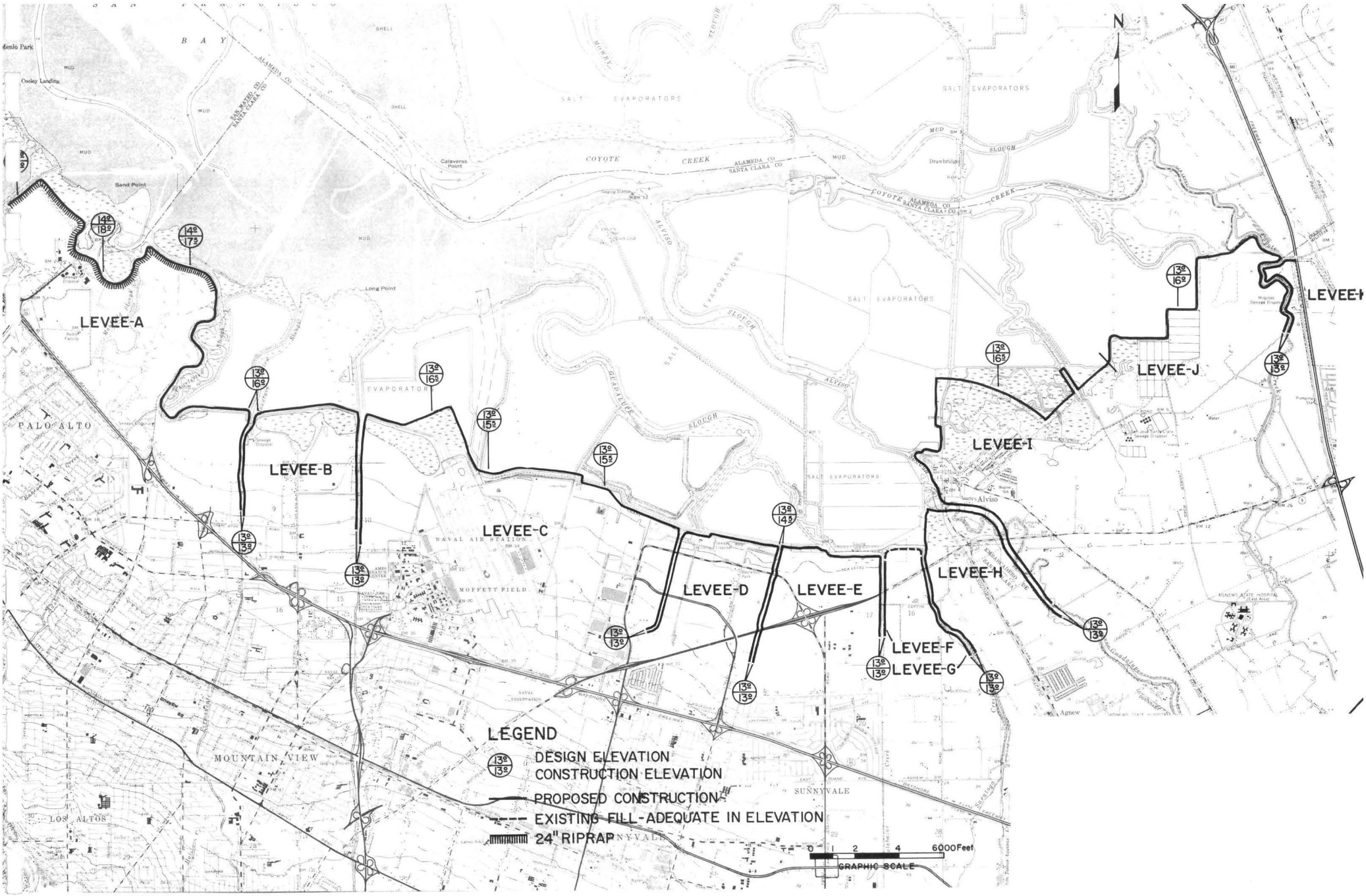


Alviso, February 1963

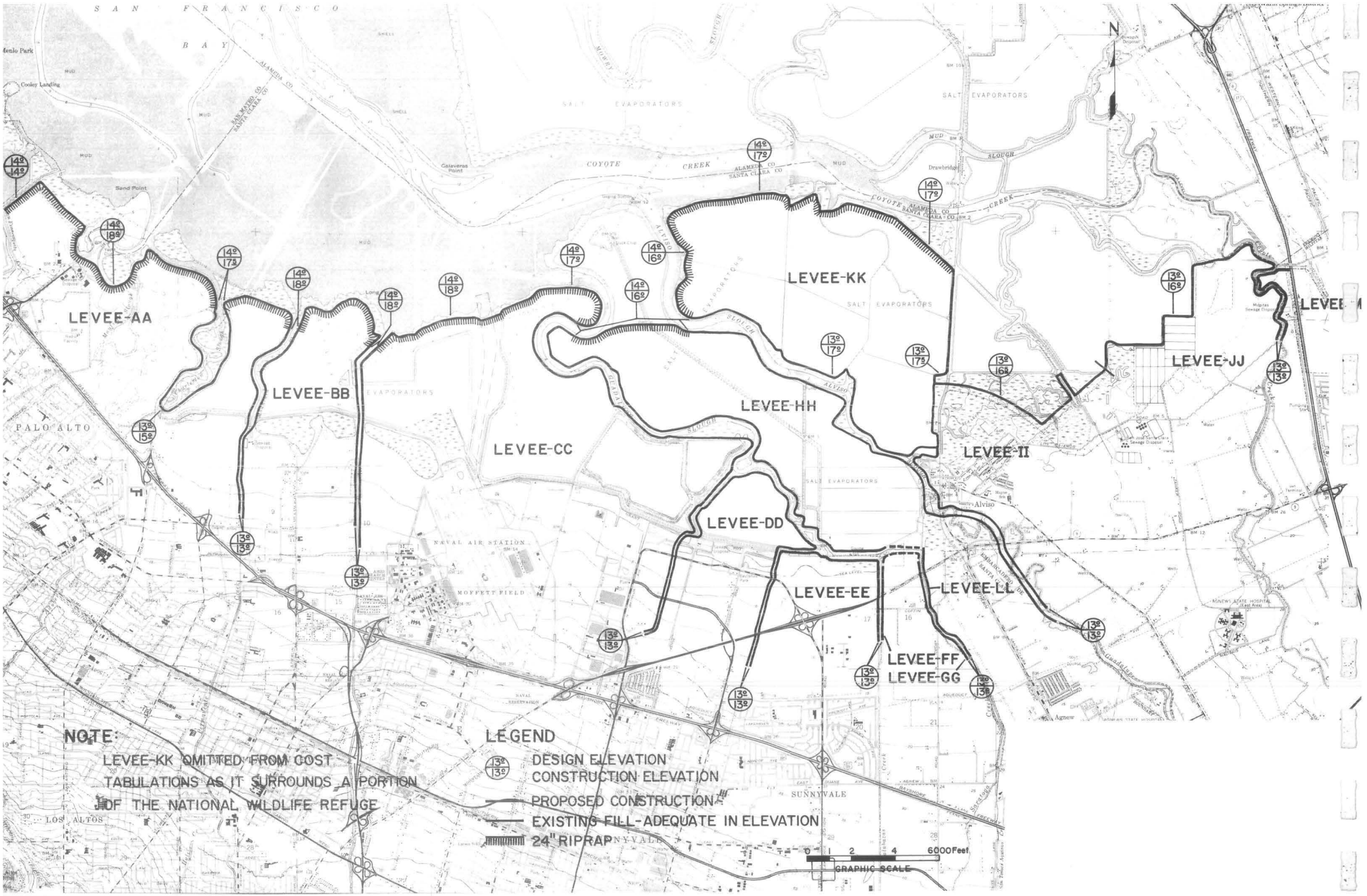
The problem of flooding is ever present in the Baylands because of the low topography and the unknown stability of the perimeter levee system.

INBOARD LEVEE PLAN

The second alternative is the Inboard Levee Plan. This would consist of perimeter levees utilizing in part the existing alignment of the inboard system extending from San Francisquito Creek in the west to Coyote Creek in the eastern side of the study area. The total length of the levees in this system is approximately 34 miles and the area protected would be approximately 7,300 acres. This plan provides no protection to the salt ponds or other wetlands. ■



INBOARD LEVEE PLAN



OUTBOARD LEVEE PLAN

OUTBOARD LEVEE PLAN

The third alternative is the Outboard Levee Plan, utilizing for the most part the alignment of the existing outboard levee system on the Bay side of the salt ponds and on the channels. The total length of the levees in this alternative is approximately 60 miles. Within this length almost 28 miles are a common alignment for levees in both the inboard and the outboard alternatives. The outboard levee will protect a total of about 14,000 acres. As finally studied, the outboard levees were not extended around any portion of the National Wildlife Refuge which was authorized by Congress in mid-1972. ■

OTHER ALTERNATIVES

Two additional alternatives were also considered for purposes of a comparative analysis of service, cost, magnitude, and impact. One is the Inboard Levee Plan with Outfall Channel Levees. The additional channel levees would provide full fresh water flooding protection to lands outboard of the inboard levees, but would provide no salt water flooding protection. This levee system is 59 miles in length, of which 25 miles are channel levees. The other alternative considered was a plan providing only outfall channel levees built to the design standards developed in the study. The total length of levees in this system is about 45 miles. ■

DESIGN FACTORS

It was determined that the elevation of the levee crests in the Outboard Levee Plan, or in the other plans where the levees are exposed to direct tidal and wave action, should be 14 feet, and the crest elevation of levees in the Inboard Levee Plan should be 13 feet. The alternative use of dredged Bay Mud, compacted imported fill, steel sheet pile cellular cofferdam construction, and sanitary land fill was considered. Because of comparative cost and availability advantages, dredged bay mud was selected as the most desirable construction material. Bay Mud would cost $226 per lineal foot for a typical outboard levee section and $172 per lineal foot for an inboard levee section. Steel sheet pile cellular cofferdam construction would cost approximately $1,100 per lineal foot, five times the cost of a dredged Bay Mud section. ■

CONSTRUCTION COST

Total construction costs for the five alternatives are estimated to be as follows:

Inboard Levee Plan	$ 57,720,000
Outfall Channel Levee Plan	68,160,000
Outboard Levee Plan	93,840,000
Inboard Levee Plan with Channel Levees	95,440,000
Do-Nothing Alternative (Land Acquisition Only)	160,456,000

Annual operation and maintenance costs for the two basic alternatives were estimated as follows:

Inboard Levee Plan	$ 369,700
Outboard Levee Plan	1,005,000 ■

ASSESSED VALUES AND TAX COST

The present assessed value of lands protected by the Inboard Levee Plan is $40,114,000, averaging $6,212 per acre. The assessed value of lands protected by the Outboard Levee Plan is $43,463,000, averaging $4,154 per acre. The value of the additional land protected by the Outboard Levee Plan over that protected by the Inboard Levee is less than one-sixth as much per acre as the lands protected by the Inboard Levee Plan.

If the costs of the alternative plans were borne by the four flood control zones whose watersheds drain into the Bay through the Baylands, the annual average tax rate per $100 of assessed value would be about 14 cents for the Inboard Levee Plan, 23 cents for the Outboard Levee Plan and 25 cents for the Inboard Levee Plan with Channel Levees. If the costs were borne solely by the lands directly benefited, the annual average tax rate per $100 of assessed value would be about $10.35 for the Inboard Levee Plan, $15.48 for the Outboard Levee Plan, and $17.77 for the Inboard Levee Plan with Channel Levees. ■

COMPARATIVE COSTS

Excluding the costs of pumping, which would not be a District cost, the following comparison of capital, operational, and maintenance costs and of the assessed value of lands directly benefitted for the three alternative plans which would provide salt water flooding protection to the Baylands is shown.

ANNUAL COSTS

	Capital	Capital	Operation and Maintenance	Total	Assessed Value
Inboard	$55,410,000	$4,015,000	$135,000	$4,150,000	$40,114,000
Outboard	87,670,000	6,353,000	337,000	6,730,000	43,463,000
Inboard with Channel Levees	93,130,000	6,748,000	394,000	7,142,000	40,197,000

Each of the levee plans has been divided into segments to enable a program of priorities for construction by segments to be developed. A weighing of the combination of costs and relative benefits, including environmental and social aspects, will help in the determination of such a program. ■

The purpose of this study was to provide information in the form of findings and not to provide conclusions and recommendations. However, some findings appear to be conclusions because the data can lead only to a single interpretation. ■

PHOTOGRAPHS

Aerial View of Santa Clara County Baylands, looking west, (by USGS).

Alviso, July 1971 and February 1963, (by Santa Clara County Flood Control and Water District).

South Bay Yacht Club, Alviso, 1914, (by San Jose Historical Society,) and South Bay Yacht Club, Alviso, 1972, (by Santa Clara County Flood Control and Water District).

CONSULTANTS

TUDOR ENGINEERING COMPANY

IN ASSOCIATION WITH
MARK THOMAS & CO., INC.
WOODWARD-LUNDGREN & ASSOCIATES
HYDROCOMP INTERNATIONAL
PHILIP H. AREND, WILDLIFE ASSOCIATES
DR. ANDREW H. TRICE

SANTA CLARA COUNTY
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General Manager	Director of Engineering

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